PRIVATE AND CONFIDENTIAL

ENGINEERING DIVISION

Visit to Holland and Germany

June 1964

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THE BRITISH BROADCASTING CORPORATION

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Section Title Page

1. INTRODUCTION 1

2. GENERAL 1

    2.1 Holland 1
    2.2 Germany 3

3. BUILDINGS 4

    3.1 Design of Buildings, Equipment and Furniture 4
    3.2 Heating and Ventilation 6

4. STUDIOS 7

    4.1 Sound Insulation 7
    4.2 Studio Acoustics 10
        4.2.1 Sound Studios 10
        4.2.2 Television Studios 12
    4.3 Sound Absorbers 12
    4.4 Control Rooms 13

5. STUDIO EQUIPMENT 14

    5.1 Loudspeakers 14
    5.2 Microphones 15
    5.3 Tape Recording 16
    5.4 Artificial Reverberation 16
    5.5 Control Room Equipment 17
    5.6 Compressors and Limiters 17
    5.7 Control of Programme Volume 17
    5.8 Miscellaneous 18
    5.9 Maintenance 18

6. STEREOPHONY 18

7. TRANSMITTERS 21

8. OTHER VISITS 21

    8.1 Amsterdam Concertgebouw 21
    8.2 Hanover Stadthalle 21
    8.3 Hamburg State Opera House 22

9. SUMMARY OF SALIENT POINTS 23

10. REFERENCES 23

PRIVATE AND CONFIDENTIAL

Engineering Division November 1964

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1. INTRODUCTION

Four members of Engineering Division visited Hilversum, Hanover and Hamburg during the week June 7th - 13th 1964. The party consisted of Messrs. Alexander Brown and Rogers of Building Department, Gundry of Sound Broadcasting Engineering Department (Operations) and Gilford of Engineering Research Department. The object of the visit was to see and discuss recent trends in the broadcasting services and in studio design and equipment.

The first two days and part of the third were spent at Hilversum where the party was shown studios, transmitters and research. The fourth day was spent in Hanover, where the principal interest was in the new studios, and the fifth in Hamburg where the party was shown round the I.R.T. research establishment, the N.D.R. studios and Hamburg Opera House. On the last day, one member of the party (Mr. Gundry) was able to attend part of the dress rehearsal of a new opera in the Opera House.

The next section of this report will record general observations about the two countries; technical observations will follow under subject headings.

2. GENERAL

2.1 Holland

On the first day in Holland the party was received by Mr. V.J. de Grijs, the Director of Engineering Services of Radio Nederland Wereldomroep, who explained the organisation of Broadcasting in Holland. For the sake of those not already familiar with the organisation, a brief summary follows.

The money for the home and overseas broadcasting services is derived from separate sound and television licences collected by the P.T.T. The fees are about £1. 4s. 0d. and £4. 0. 0. respectively, and the revenue, after deduction of collection fees, is allocated by the Ministry of Education among the various services. These are as follows:-

The Netherlands Broadcast Transmitter Company: This holds both the sound and television transmitters but is a paper organisation only, making no profits.

Programme Companies, run by political or religious organisations. These are:-

K.R.O.	Roman Catholics
N.C.R.V.	Calvinist Protestants
A.V.R.O.	Liberals
V.A.R.A.	Socialists
V.P.R.O.	Liberal Protestants

The two main religious groups share one transmitter, the two political groups the other. The V.P.R.O. have some time allocated on both. Each company has its own studios.

The Overseas Service : Radio Nederland Wereldomroep (R.N.W.), which also has its own studios.

The Nederlandsche Radio Unie (N.R.U.), which is a service organisation, supplying engineering facilities, music, musical instruments, buildings and technical equipment to the programme companies. It also supplies engineering staff and musicians, including three orchestras, of which the largest is the Radio Philharmonic with 100 players. Over all these supply matters it has complete control. All technical areas are kept locked and the programme companies are not allowed to use the facilities without N.R.U. staff being present, nor to borrow tapes or equipment. The only exception to these generalisations is that Wereldomroep has its own engineering services under Mr. de Grijs.

N.R.U. also carries out all research on sound broadcasting.

The Nederlandsche Televisie Stichting (N.T.S.): This is the television equivalent of the N.R.U. The two bodies are separate but linked by common directors and regular interchange of ideas and information.

The N.R.U. premises and all the sound studios are situated in Hilversum, except for small announcement studios run by N.R.U. in the transmitter buildings at Groningen, Maastricht, etc. The television studios are at Bussum between Hilversum and Amsterdam, the main transmitters at Lopik. The N.T.S., N.R.U. and television studios will eventually be concentrated at the Radio City Site on the outskirts of Hilversum.

In the afternoon of the first day, the party was taken to the transmitters at Lopik where it was received by Mr. Maas. After inspecting the old M.W. transmitter building, we went to the new tower which radiates television programmes, V.H.F. sound including stereophony, and V.H.F. paging for doctors and emergency organisations. This last service is connected to the telephone system (automatic throughout the country), and dialling from a doctor's surgery causes one of four different code signals to be received on a receiver in his car.

On the second morning we were received at the N.R.U. premises by Dr. J.J. Geluk who also took us to the V.A.R.A. studios and in the afternoon to the Radio Centre. The third day until the time for departure for Hanover was taken up with visits to the N.C.R.V. and K.R.O. studios and to the Concertgebouw in Amsterdam.

Three of the party attended a chamber concert in the small hall of the Concertgebouw on the second evening.

2.2 Germany

There are nine individual organisations responsible for broadcasting in West Germany; of these, seven cover the main areas, North, Central, West, South, the Saar, the South West and Bavaria, while the remaining two cater for the special areas of Bremen and West Berlin:

B.R.	(Bavaria)	S.F.B.	(West Berlin)
H.R.	(Central)	S.D.R.	(South)
N.D.R.	(North)	W.D.R.	(West)
R.B.	(Bremen)	S.W.F.	(South West)
S.R.	(Saar)		

Norddeutscher Rundfunk, responsible for the North, has headquarters in Hamburg and another studio centre at Hanover. For political reasons it was considered necessary to have a concert studio for the N.D.R. orchestra in Hanover. Some attempts to combine, as a municipal venture, with the local council to produce a concert hall fell through and the project went ahead as an orchestral studio with audience.

Owing to an accident, Dr. W. Kuhl of the I.R.T., who was to have met us at Hanover, was unable to travel. We were received by Dr. Schiesser and Dr. W. Kath of the I.R.T., and Mr. Kreib of N.D.R. A visit to two concert halls known as the Stadthalle was included. There was general discussion on concert halls with particular reference to the New York Philharmonic.

In the new large music studio, we were able to hear a recording session with the light orchestra of 72 players and to take part in a listening test which will be described below. There are 1200 seats in this studio and about 120 public performances take place per year.

At Hamburg the same two I.R.T. engineers received us and also Dr. Kuhl with whom we had some fruitful discussions. Here we spent the morning at the I.R.T. laboratories, lunching at the N.D.R. and resuming discussion at the I.R.T. in the late afternoon. The intervening time was filled with a brief visit to the State Opera House which had been arranged by our hosts (with some considerable difficulty as there were continuous rehearsals in progress for a new opera and the management was unwilling to admit anyone at all).

The evening we spent at the N.D.R. studios watching a light music stereophonic recording.

3. BUILDINGS

3.1 Design of Buildings, Equipment and Furniture

In Holland the five programme companies have premises which are mainly dispersed around the perimeter of Hilversum, itself a pleasant garden city, and are mainly situated in semi-rural surroundings where there is little traffic noise and no low-flying aircraft.

The buildings, whether old or new, are normally specially designed for their purpose. They are well maintained, and mostly set in very pleasant grounds well laid out with trees, shrubs, lakes and lawns. The most recent examples are the new building for R.N.W. and the new Radio City still in course of construction, to contain television studios and the headquarters of N.R.U. (till now perhaps the worst housed of the various sections).

Responsibility for building programmes lies with N.R.U., which has a small building organisation of its own. This undertakes maintenance and minor alteration work, and collaborates with Dr. Geluk in acoustical experiments. N.R.U. also has engineering, sheet metal and carpentry workshops which are able to manufacture technical equipment of metal and timber construction, and are turning out some very interesting work to a high standard of design, construction and finish.

Most of the building programme of new work and anything but minor alterations is undertaken by architects in private practice. They are also asked to design the casings for equipment such as technical desks and studio loudspeakers, which are standard supply to the programme companies, and are also consulted for general decoration schemes, choice of furniture, clocks, etc. The scale of operations is smaller than in the BBC and some continuity of experience is obtained by employing a limited number of three or four architect firms, who thus gain considerable knowledge of the technical content of the design. The results are unified and logical schemes which satisfy the technical and programme staff in terms of function and appearance.

Of special interest were the most recent schemes, one for R.N.W. and the other the project Radio City which is to house the new television studios and N.R.U.

The new R.N.W. (External Services) building is situated in an attractive park-like setting on the outskirts of Hilversum, and was designed for the purpose by a Rotterdam firm of architects. The building is very modern in design and contains eight small G.P. Studios and an administration block, all linked by a spacious entrance foyer.

A feature of the building is the sense of spaciousness and light, (including the studios which all have external windows) and the sense of contact with the well maintained grounds. The studios are contained within a structure which is physically separate from the remainder of the building. They are built at approximately ground level and are carried on slab concrete walls resting on sand (Fig. 1). The studios are built in groups of four around a common access hall. Only one group has so far been constructed; the remainder are planned for future development. The administration block, although built over the studios, is entirely separate from them. It is carried on its own structural frame, which passes through the studio block but has no contact with it. Although sited in a semi rural area, double glazing is used throughout the offices as well as the technical areas.

The new television studios in Radio City follow the pattern of linear expansion established at Burbank by C.B.S. twenty years ago and illustrated in Fig. 2. The two main studios at present under construction each has a floor area of 5,400 sq.ft. and the four others are planned at 3,375 sq.ft. The height of the lighting grid is 27 ft and the total height allowed for the building is 45 ft.

In Germany the Hanover Rundfunkhaus was the most interesting building we visited. It is situated in a very open position adjoining an artificial lake and was designed in three stages over a period of fifteen years. The earlier administration block had been completed as a post war building and now a new section has been added comprising a large studio and its ancillary accommodation. The architectural design is uncompromisingly modern and clean cut. The main concert studio stands out as a large hexagon on plan and in section and is a design which was arrived at from architectural and town planning considerations. The acoustic and sound insulation solutions were achieved by collaboration between the architects and Dr. Kuhl of the I.R.T.

Access is by way of a large entrance foyer beneath the auditorium. This hall is fully glazed on three sides and reveals the main studio independently supported on two main columns which carry the main cantilevered seating area. The design of the foyers is conceived on a grand scale. No structural elements are in evidence except where unavoidable. The glazed walls adjoining the entrance doors, for instance, meet at an angle of 35° in a glass mitre 18 ft in height. Where structural elements are required care has been taken to avoid clumsy detailing. Cold rolled sections of steelwork with sharp arrises have been used, stove enamelled black, with no cladding.

The foyer floor is black asphalte with a medium aggregate filler, which is used to avoid reflections with such a large glass enclosure.

The melamine-faced counter tops are constructed with invisible butt and edge joints and altogether the building evinces considerable quality in architectural thought and scrupulous workmanship.

Externally the building is clad with stove-enamelled steel plates which contrast with the almost unsupported glazing below and emphasise the hexagonal shape of the studio.

The colours outside, in the foyer and in the ancillary accommodation, are limited to black and white, the colours inside the auditorium being softened by the addition only of natural wood.

The lighting in the auditorium was entirely tungsten, comprising approximately 400 tungsten spotlights in 10 rows, plus 10 rows of tungsten fittings in reflecting troughs shining upwards on to the perforated metal ceiling (stove enamelled white). The interior decor gave the impression of artistic control, as in Holland.

3.2 Heating and Ventilation

No unusual ventilation systems were observed in Holland in any of the buildings visited. The usual precautions were taken to ensure good sound insulation between technical areas. There were no high velocity systems. Noise levels appeared subjectively to be within the tolerances imposed by the BBC's acceptable background levels. Conditioned filtered air was usual and there was a tendency to use plenum chambers in the void over the acoustic ceiling rather than outlet grilles as a method of distribution.

Heating and ventilation in the German studios were again observed to be conventional in type and are housed in the basement areas.

In the Hanover studio noise is well below the BBC required curves. It was possible to examine an elaborate silencer which gave 65 dB insulation from input to output.

Air speed in ducts is 9 ft/sec but only 1 ft/sec at grilles.

The ventilation plant at basement level is hung from posts suspended resiliently off the floor, but this is an expensive afterthought, the original arrangement of suspension from the ceiling having to be abandoned after noise problems.

4. STUDIOS

4.1 Sound Insulation

The sound insulation problems in the Hilversum studios are trivial compared with those of BBC studios since all the centres except K.R.O. are built in comparatively open country or suburban surroundings with little traffic noise and no low flying aircraft. This dispersal does, apparently, cause some adverse comment among artists, though it should be pointed out that the distances between the town centre and any of the premises is far less than that, for instance, between Broadcasting House, London, and Television Centre or Maida Vale. It may be the distance from any principal cities which is the main objection.

Sound insulation is therefore necessary mainly between different parts of the studio centre rather than against external noise.

The same is broadly true of the Hanover and Hamburg studio centres, though additional protection is required in Hanover against fast-moving traffic on the road between the buildings and the Maschsee on the edge of which they stand.

All the Dutch programme companies take elaborate precautions for sound-insulating their studios.

Where necessary, studios are floated on 'S' type steel springs and noisy areas are planned away from them. A typical arrangement for music studios is to house the control rooms over a 'transit' room separating studios and comprising an instrument store, a loading bay and a sound lobby.

In the Wereldomroep buildings the transmission of structure-borne sound between the office blocks and the studio blocks is reduced by mounting each block on a separate vertical reinforced-concrete panel resting on the sand subsoil.

A similar construction is used for the recently-completed large studio at Munich. This is noted in BBC Research Report No. A-057 which covers a visit in 1959 when the studio shells were just finished.

Some major planning consequences result from the Dutch use of sound resisting doors and windows and from the disciplines enforced in the usage of studios and control rooms:

(1) Single Schmitz doors are used as access to studios from corridors and control rooms. These doors can be designed for 45 - 50 dB insulation, but these figures can only be achieved with a pressure seal; it is therefore

obligatory to use lever handle closers. Doors cannot be opened during transmission; in fact, the discipline is so strict that they are always locked when the studios are not in use, the appropriate Head of Engineering only having a master key. The result of this usage is to obviate sound cut-off lobbies, thereby effecting a considerable saving in space. Thresholds are provided everywhere as it would not be possible to achieve the required insulation without them.

Schmitz doors are universal in Germany and the same disciplinary arrangements as in Holland ensure that sound cut-off lobbies are not required. They are fabricated in steel sheet and are a factory made standard product in almost universal use for studios in Northern Europe.

The sound resisting door to the free-field room in the N.R.U. laboratories was withdrawn from the door opening on overhead rails (as at B.H. Extension) but the arrangement saved some space due to the door being pivoted.

(2) In Holland, broadcasters are said to prefer an environment of natural light in studios and almost all the more recent studios, recording and dubbing rooms have windows to the open air and also in some cases to corridors. In one suite of continuity studios and control rooms there are windows in all four walls - external, corridor and observation windows. This practice certainly provides an atmosphere which is very bright and cheerful, and avoids that sense of enclosure which is often felt in fully internal rooms.

Many studios have daylight through triple or quintuple glazing. The insulation claimed for one quintuple system was 80 dB. This requirement (daylight) precludes the screening of studios from ambient noise by offices (as in B.H. tower). Condensation problems to outside windows were overcome with thin double glazing using a dehydrated air space similar to some proprietary British types.

Insulation through double glazing between control areas and studios is as normal BBC practice, and the detail at V.A.R.A. bore a striking similarity to that used in B.H. Extension basement. It appeared that no provision was made in the most recent studios for removal of one pane for cleaning; in one case mitred glass was used where observation was required into two adjacent areas (see Fig. 2), but in others one pane was accommodated in a hinged frame.

Prevention of transmission through ductwork is achieved by normal methods; ringing is avoided in one installation by the use of asbestos instead of galvanised steel, but our information was that the choice was made on grounds of cost.

Airborne sound insulation inside the studio premises in Hilversum is largely obtained by double walls of woodwool blocks, plastered on the studio side and elsewhere where appearance counts. One demountable partition seen in between non-technical areas consisted of two skins of plywood with a porous material. 40 dB mean insulation was claimed. Between offices even fanlights were double-glazed.

The Dutch have similar difficulty to our own in ensuring leak-proof joints round windows and they have developed a small loudspeaker for tracing these leaks. It differs from our attempts in the past by having a seal consisting of a thick ring of polyurethane foam round the loudspeaker cone thus confining the sound to the area of the cone itself. We propose to try a similar arrangement.

We found that both the Dutch and the Germans were in agreement with us that at least 70 dB mean insulation was a necessity for all exposed studio roofs. The roof of the new Hanover studio has a mean value of 80 dB. It was developed by Dr. Kuhl using scaled models. We queried whether the so-called coincidence effects causing severe reductions of sound insulation at certain frequencies would behave in a scale model in the same manner as lumped constant effects, and Dr. Kuhl replied that they do, quoting Cremer as authority.[*]

In the Hanover studio elaborate precautions have been taken to insulate from outside noise sources. All parts of the auditorium except the main trusses are supported on 'S' shape steel springs. The trusses were normally supported for structural reasons and because the radiating area of their surface was relatively small. The insulation of the wall-structure is in the region of 75 dB. Protection against footfalls on main staircases is provided by a thick $\frac{3}{4}$" resilient insert between the concrete strings and treads and a spring restraint holds the staircase from slipping.

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[*] Further investigation confirms this: the critical frequency for a sheet material is proportional to $\sqrt{m/B}$ where m is the mass per unit area and B is the stiffness.

$$m \propto \text{thickness}$$

$$B \propto (\text{thickness})^3$$

$$\therefore f \propto \frac{1}{\text{thickness}}$$

i.e. the critical frequency will be correctly scaled if all frequencies are increased in the same ratio as the dimensions, including the thickness, are decreased.

The insulation of the roofs to the new Hilversum television studios is to be provided by plastered wood wool slabs 12 inches apart (see Fig. 3). One would not expect more than about 55 - 60 dB using this method. Hilversu is 25 miles from Amsterdam airport and does not appear to be on any major flight route.

In the Hanover studio television cables are brought into the building through a lined duct to avoid airborne transmission.

4.2 Studio Acoustics

4.2.1 Sound Studios

Small studios in Holland were found to be generally liver than ours, the average reverberation time for speech studios being 0.5 sec as compared with between 0.3 and 0.4 sec in BBC studios. The effect on transmission was less marked than this would imply, owing to closer working (35 to 45 cm) for speech with cardioid and other directional microphones.

Acoustic treatment in the small studios is rather stereotyped, using 12% perforated hardboard or perforated fibre tiles on the ceilings with alternate strips of plain and perforated plywood panelling on the walls to provide diffusion as well as absorption. The floors are generally uncarpeted cork linoleum, though some squares of haircord carpet were seen where acoustic adjustment had been necessary. The perforated ceilings also act as air diffusers for the ventilation systems, the volume between the false and structural ceilings acting as plenum chambers. The bass absorptio mainly provided by plywood panelling, was supplemented in some instances by sharply-tuned Helmholtz resonators of which more will be said below.

Control rooms in Holland are similarly treated.

In the larger studios the treatment is more varied. There is widespread use of chipboard panels surfaced with Mikroporfolie (a porous glass-fibre wafer material) to obtain absorption over a wide band. The vibration of the panels provided the bass absorption, the porosity of the surface the middle- and upper-frequency absorption. Diffusion in the V.A.R.A. studios was by polythene diffusers of wedge shape on bases approximately 0.7 m square. Some of these, surrounded by the 1 m^2 chipboard panels may be seen in Fig. 4. Only one example of variable acoustics was seen; the alteration was achieved by swinging hinged doors through 180° to expose backs with absorption characteristics complementary to the fronts. On the walls in the spaces behind the doors, cut acoustic tiles were supported on brackets. In this studio these complex measures had evidently failed to supply enough absorption as about 120 glass-fibre pads about 0.5 m square were suspended from the ceiling (Fig. 5).

Acoustic screens, made of light gauge pressed steel with one face covered with fabric backed with porous absorption may also be seen in the same figure. The screens are light and can easily be moved by using the round base as a wheel. There is no adequate method of butting screens to form an enclosure although magnetic catches are provided to joint them, nor any way of roofing them over. No screens have transparent panels.

The largest music studio in Hanover, completed about a year ago, is of special interest. Drs Kuhl and Kath were responsible for the acoustic treatment in consultation with the architects
Apart from the specially designed seating in this hexagonal hall and some new corrective treatment above the false ceiling, the only absorbers are the plywood resonators.

These are arranged in the form of rectangular coffering to improve diffusion in the studio[1], a method which was adopted in Maida Vale Studio 1 and which is being consistently advocated in Research Department. The same device is used in the new studios in Munich.[2] The absorbers, which have been under development for some years, are described in Section 4.3 below.

A middle-frequency resonator has been provided above the false ceiling level on top of hardboard reflectors; this consists of P.V.C. film 0.04 inches thick over ¾" rockwool and has maximum absorption at 1.8 kc/s. The false ceiling consists of perforated steel (open area 36%) in the form of angled plates suspended from the main trusses.

The absorption provided by the upholstered seating is sufficient (due to unusually high backs) to prevent large differences in reverberation time between the hall empty and full.

A timber reflector, approximately 6 ft (2 m) in height, is provided to head level behind the orchestra and may be seen in Fig. 6.

Sitting in the studio we felt that there was some loss of top on the music but this was not evident when listening by means of a slung microphone. The users thought this was partly due to the effects of interfering reflections from the ceiling and Dr Kuhl was in the process of carrying out experiments to cure the trouble by introducing sheets of hardboard to form a false ceiling, thereby reducing the interval between the direct and first-reflected sound from 35 ms to 25 ms in a typical position.

During our visit a subjective acoustic test was carried out. Some musicians played solo pieces segué on the stage followed in quick succession by the placing of the hardboard reflectors and a repeat of the segué solos. No difference was apparent in the body of the auditorium but the violinist seemed to detect a ring or colouration at about G below A-440. He played this note repeatedly, gesticulating to his colleagues whose interest seemed only faintly aroused although they repeated the note on their own instruments. No colouration was noticed by the BBC party and Dr Kath seemed unperturbed about the demonstration.

4.2.2 Television Studios in Hilversum (Mr. Moll)

The two permanent studios in the Radio City in Hilversum are nearing completion. They are similar in size to studios 3 and 4 at Television Centre.

They are being built in a 20-foot thick bed of sand which covers the whole site, and which is thus conveniently on hand for the preparation of concrete (Fig. 7).

The designed reverberation times are about 1 second, obtained largely by the use of cemented woodwool for the walls, the unfinished face inwards.

In a temporary studio now in use but later to be a scenery store, lighting intensity and lighting and technical equipment is similar in many respects to that at Television Centre. The reverberation time appeared to be about 1½ seconds, far higher than would be tolerated here, even in a temporary studio.

At Bussum, Fernseh television equipment was everywhere in evidence, the sound equipment being of Telefunken manufacture or N.R.U. design.

We saw no television studios in Germany.

4.3 Sound Absorbers

The sound absorbers seen in Hilversum were all of types well known to us. Bass absorption was generally by plywood panelling, though single Helmholtz resonators were also mounted in some of the studios.

As an alternative to perforated plywood, knucklebone strip coverings were seen in several studios. We were assured that these were transparent up to high frequencies, contrary to all experience here but we were conscious of an increase of reverberation at high frequencies. We also considered the optical effects of the equally-spaced slats worse than those associated with the perforated dark or natural-coloured plywoods.

We had an interesting conversation with Mr. Van Leeuwen of N.R.U. about Helmholtz resonators as absorbers. He agreed with our view that it is more difficult to obtain reductions of decay times to 0.3 seconds such as we require than to 0.6 sec or more which is usual in the Dutch studios.

We were shown Helmholtz resonators of the type used in studios and they bore a close resemblance in the method of frequency adjustment and other respects to those developed by Building Department. They do not appear to have had the same difficulty in maintaining high enough 'Q' values. Fig. 8 shows a section through one of their resonators, drawn from notes made at the discussion. We discussed methods of calculation and gained ideas which may make a renewed attempt at reduction of colourations in small studios worth while.

At the I.R.T. in Hamburg, we were also shown Helmholtz resonator absorbers consisting of hemispherical perspex mouldings with holes up to four in number cut in them. The holes are fitted with moulded polythene rings in two sections arranged to close into one another like a watch case, trapping a disc of gauze for damping. Dr Kuhl stated that these resonators were equivalent, when mounted in a corner, to 3 m^2 of perfect absorber.

For general bass absorption, the Germans depend on carefully constructed wood panelling in the form of closed plywood boxes, the interiors of which are half filled with rockwool. This has been used in the Concert Studio in Hanover. The plywood is 17 mm thick, loaded as necessary with plywood blocks. The lowest bending frequency determines the resonance, modified by the stiffness of the air in the space. Damping is given by the friction at the edge fixings. The rockwool is not primarily for use as damping, which is not possible in an enclosure so small as compared with the wavelength, but it forms a heat sink and thus makes the air compressions and rarefactions isothermal instead of adiabatic. This lowers the resonance frequency of the panel for a given air depth. They use two sizes of plywood, covering the ranges 60 c/s to 120 c/s and 120 c/s to 150 c/s. Such resonant absorbers are measured only with pure-tone sound, as the use of warble-tone or noise gives misleading results if the resonances are very sharp.

We asked Dr Kuhl whether he had any experience of resonant bass absorbers of asbestos-cement or other fireproof materials but he was unable to help.

4.4 Control Rooms

In both countries, all control rooms are being made adaptable for stereophony. The main control desk is usually several feet away from a very large observation window with two loudspeakers between the desk and the window subtending a suitable angle at the operator's position.

Acoustic treatment was similar to that of talks studios and the result was a longer reverberation time than we would consider the optimum.

In some of the Dutch control rooms all the control equipment has for some time been duplicated, even the loudspeaker, the main and standby loudspeakers being located at the ends of a long cabinet over the observation window. This made it very easy to go over to stereophony.

In some instances the observation window covered the entire wall facing the studio. In one case, when Aaron Copeland was conducting his "Billy the Kid" with the Radio Philharmonic Orchestra, the stereophonic reproduction, together with the very wide window, produced to some of the party for a while the illusion that the window glass was absent.

4.5 Monitoring Levels

We enquired at all organisations visited about their policy with regard to monitoring and listening levels, and the situation is somewhat confused in both countries.

In Holland, relationships between domestic and studio listening levels do not appear to have been considered at all. We were told that monitoring should be carried out at the highest possible levels but that frequently operators did not do so. It was conceded that the levels of continuity listening might be relaxed to avoid fatigue and because control of quality was not there the primary object.

In Germany, Dr Kuhl explained the position by saying that in his opinion peak levels should be about 85 phon; engineers were glad to keep monitoring levels down since they were aware of the possibility of damage to hearing by continuous exposure to high levels, but conductors preferred the levels to which they were accustomed in the middle of an orchestra and invariably insisted on hearing replays with peak levels up to 15 phon higher. At an N.D.R. programme which we attended in Hamburg the monitoring level appeared to be at least 100 phon on the peaks.

In the Dutch overseas services, no frequency corrections to simulate overseas listening conditions are used, all monitoring being carried out with "flat" amplifiers.

5. STUDIO EQUIPMENT

5.1 Loudspeakers

In Holland the loudspeakers generally used have Philips units mounted in enclosures made by N.R.U. The latest version has a single unit and the enclosure capacity is about five cubic feet (0.14 m^3). They gave good stereophonic effect, but the quality was somewhat hard and metallic, and not so natural as that from the older and larger loudspeakers still used in many studios. Exceptionally, the music studio in the Wereldomroep used large loudspeakers each consisting of a Quad electrostatic speaker mounted on top of a large enclosure containing a low frequency cone and taking over at about 150 c/s. We did not hear these, but similar units demonstrated by Philips during a previous visit gave excellent quality with ample volume output, at least in stereophony.

In Germany the loudspeaker using a sphere for the high-frequency radiator, and incorporating a large number of small cone loudspeakers, failed to obtain general acceptance because of its lack of presence. The latest type uses a much smaller number of units within a normal rectangular section enclosure. A switch enables the units facing upwards and sidewards to be switched out of circuit, thus raising the 'presence' of the reproduction. These loudspeakers cost DM 1800 without amplifier. The 35 watt amplifier cost a further DM 1000. However, this loudspeaker will deliver only 102 phons at 2 metres distance. This is not considered sufficient by the music department, and in both Hanover and Hamburg for stereophony they were using in the cubicles two loudspeakers made by Klein and Hummel in cabinets 5 feet high, 17 inches wide and 14 inches deep each using 3 Electrovoice units. These were capable of 110 phons at 2 metres! Both these types of loudspeaker gave excellent well balanced quality. The effect of the presence switch was very noticeable, the condition of greater presence being nearer to our LS5 as far as we could judge. In the new loudspeakers the amplifiers have a flat response, and no adjustments are now made for room acoustics. However, the volume controls on the mixing panels are frequency compensated at lower listening levels.

5.2 Microphones

In Holland nearly all the microphones used in studios use the cardioid condenser capsule developed by N.R.U. at least five or six years ago. These appear with several types of head amplifier using an EF86 valve, described in earlier reports of visits to Dutch studios. In the latest versions a form of modulated R.F. oscillator using a bridge is used in place of a conventional head amplifier. A stereophonic form of this was seen, but additionally some Neumann SM2 condenser microphones are used for stereophony.

The Wereldomroep uses mainly Neumann condenser microphones in its music studios, as described in this report under Stereophony, but we saw one N.R.U. microphone and one S.T. & C. type 4033A.

In Germany, Hamburg and Hanover were using exclusively Neumann microphones in all the studios we saw. These consisted of M49, KM54, KM56, U267 and SM2 types (the SM2 in some cases being of a later type using a plug-in valve). There were no basically new types of microphone.

5.3 Tape Recording

In Holland, Telefunken equipment appeared to be favoured and most of the machines were of this make. It is usual to use 7½-inch/sec for speech if no editing is proposed, but 15-inch/sec on music and all speech tapes on which editing will be required.

The tape used is Agfa PER525, a polyester base tape which requires a lower bias and gives less printing trouble than previous Agfa tapes. For transcription tapes double-play PE 31 or triple-play PE 61 is used to reduce freight charges.

Closed-loop cassetted tapes are used in some instances for standard announcements, in conjunction with 'Spotmaster' machines. Their biggest use is in the overseas service, to play opening and closing announcements and the signature tunes.

No unusual developments in this field were observed in Germany. Telefunken machines are the most commonly used.

5.4 Artificial Reverberation

We saw the echo rooms in Hilversum equipped with Helmholtz resonators and brick diffusers which have been described in the E.B.U. Journal, and Fig. 9 is a photograph of one of these.

Apart from these rooms, all added reverberation appeared to be from plates, on which research is still continuing in both countries.

At I.R.T. Dr. Kuhl explained his ideas on further developments. Subjective experiments had shown that there should be at least 3 resonances per c/s to avoid colourations in the 1000 to 1500 c/s region, fewer being necessary outside this band. Reverberation plates have equal numbers of resonances per c/s irrespective of the frequency range and therefore tend to have colourations centred at about 1.2 kc/s. Reverberation rooms have a steeply rising relationship between the number of resonances and frequency and hence have prominent low-frequency colourations.

To increase the number of resonances, a plate of larger area or smaller thickness must be used. At present neither seems a practical possibility.

Dr. Geluk said that he was working on a smaller type of plate which he believed would overcome some of the limitations of the Kuhl plate, but asked us to keep the actual proposals confidential.

We discussed the acoustic delay tubes which he uses to interpose a delay in the reverberant channel in his echo rooms. We were unable to find out why he has apparently more success than we have had with these delay tubes.

For stereophonic programmes the double-transducer plate was generally favoured, sometimes using M and S signals on the two systems.

5.5 Control Room Equipment

In both Holland and Germany the mixing disks have horizontal slider faders, using carbon tracks. These evidently give much less trouble with noisy operation than stud types. All new Dutch equipment is stereophonic, and transistorised. In Germany it is not considered desirable to use transistorised mixing equipment, at least until all transistors can be of the silicon type. Germanium transistors they believe are too easily damaged by overheating. They believe improved noise levels should be obtained from condenser microphones using R.F. transistor oscillators, but that the full benefit of these would not be obtained if the rest of the equipment were transistorised, their valve amplifiers being particularly quiet.

The I.R.T. has designed a new transistorised P.P.M. using 14 silicon transistors, with a consumption of 10 mA at 12 volts, and having a normal sensitivity giving indication down to -55 dB, with maximum sensitivity giving indication down to -75 dB. There is no change in sensitivity over the temperature range of 0° to 60°C, only 0.2 dB up to 80°C, and 0.5 dB down to -17°C. However, the supply voltage must be stabilised within 0.3%.

5.6 Compressors and Limiters

In Holland the use of limiters or compressors is confined to the transmitters. None are used in the studios nor at the transmitters for stereophony.

5.7 Control of Programme Volume

The Germans use much the same speech to music ratios as the BBC, e.g. speech 8 dB below peak music for symphonic material, but 8 dB above peak music for 'pop'. However, their news bulletins are radiated at 2 dB above full peak modulation, i.e. with 2 dB of limitation. This is 6 to 8 dB above ours. We were told they were keen that as many listeners as possible in East Germany should be able to hear the news. They realised that this made the news sound very loud relative to other material, but did not think it any necessary part of their job to equalise loudness between succeeding programmes. This is the listener's job. They attempt reasonably even loudness only within the period of any one programme.

Experiments are being conducted with a meter having two indicators. One shows peak volume with a flat frequency response. The other has a response falling at each end of the frequency range, to -12 dB at 40 c/s and -6 dB at 10 Kc/s, and its registration time is increased to 100 milliseconds compared with 10 milliseconds for the true P.P.M. This second indicator is said to give a much better indication of loudness, and though it is obviously unsuitable for controlling the peak value of the programme, it could help to level loudnesses within the permitted range on the P.P.M.

5.8 Miscellaneous

Chart recorders are still in use in Holland to keep a continuous record of modulation level (see Research Report No. A-052). The records are destroyed after a week if no dispute arises with either P.T.T. or the transmitter people.

Two examples of the counter-balanced microphone suspensions seen in several of the studios in Holland are shown in Fig. 4. The Germans prefer to use the remotely-controlled suspensions, using three slings with electric winches, manufactured by E.M.T.

All new N.R.U. equipment is or will shortly be transistorised. As an example, they have a new P.P.M. with a new type of characteristic; the rise time is 3 ms followed by a 300 ms pause at the top before decaying in 0.5 sec.

5.9 Maintenance

In Holland there was a feeling that repeated interference with equipment by routine maintenance tended to produce faults which would not otherwise occur. The normal routine was to take each studio suite out of service completely one week in nine but this is now thought to be too frequent.

In some studio centres there is a workshop occupied entirely in reclaiming used tapes. Tapes with up to seven splices are issued for re-use and the service pays for itself several times over. Special applications have to be made to N.R.U. for the use of a new tape.

6. STEREOPHONY

In both Holland and Germany there is considerably more activity than in Britain. In Holland all new studio installations are designed for stereophonic working, using transistorised equipment designed and made by N.R.U. The only exception to this is in the World Service or Nederland Wereldemroep studios, where their only studio of any size, a general purpose music studio of about 25,000 cu. ft. volume, is equipped with a Philips transistorised panel having 14 monophonic channels, each with a Panpot enabling it to be split between the two outputs required for stereophonic working. Normally all programmes recorded in this studio are recorded in stereophony, and stereophonic disks are processed from these recordings as Transcription issues. For monophonic reproduction A and B, or M, derived from the stereophonic tape is used. This studio, unlike other Dutch studios, is equipped mainly with Neumann microphones. These include the stereophonic type SM2 and the monophonic types KM56, U67 and U47. Every channel has means of adjusting frequency response. Echo is derived from two E.M.T. plates, one fed to each stereophonic channel. This was said to give more satisfactory reverberation than one plate with two microphone outputs; though this did not agree with the views of Dr. Geluk and others in the domestic services nor of the Germans.

The other stereophony equipped studios which we saw were in the V.A.R.A. and N.C.R.V. studio blocks. The loudspeakers were mounted high up on each side of the large observation windows. The microphones used were chiefly monophonic condenser cardioid type made by N.R.U., but there were one or two examples of the double cardioid type using transistorised (R.F. oscillator type) head amplifiers, and also of the Neumann SM2 variable polar diagram stereophonic microphones.

In the V.A.R.A. and N.C.R.V. studios the microphone technique is based, especially in light music, on multi microphone monophonic balances, but with each microphone steered by 'Panpot' to give appropriate outputs to the left and right channel for the desired position of its output. Sometimes one or more of the monophonic microphones may be replaced by a stereophonic crossed coincident pair. In the N.C.R.V. studio the Radio Broadcasting Orchestra (an orchestra similar to our BBC Concert Orchestra) stereophonic crossed pairs were being used as a main microphone, on the woodwind, and on the brass, and there were 6 additional monophonic microphones, three on percussion, one on harp, one on solo double bass and one on solo violin. All were cardioid condenser microphones. Reproduction was good. Monophonic microphones tend to give localised spots rather than a continuous picture, but the Dutch use more reverberant studios than are favoured by the BBC, and also add artificial reverberation, thus blurring the spot definition and giving an acceptable continuous stereophonic picture with reasonable definition of position, not too much upset by relative changes in level on the monophonic microphone channels.

Stereophonic Broadcast Output

In the week of our visit Hilversum radiated, on the Zenith-G.E. or Pilot Tone system, 25 programmes of lengths half an hour to over an hour each. On at least one occasion the two Hilversum programmes 1 and 2 were broadcasting overlapping stereophonic programmes. A high proportion of the material is recorded in their own studios, nearly all being music both serious and light. They have, however, broadcast a full production of 'Hamlet'. The continuity control rooms in the V.A.R.A. and N.C.R.V. buildings are both equipped for stereophony. Stereophonic transmissions are fed to the transmitter at Lopik, about 15 miles away, on three lines carrying respectively the left and right signals to the V.H.F. transmitters, and the sum signal to the Medium Wave transmitters. It is planned to feed the satellite V.H.F. transmitter with stereophony by the existing R.B.R. system, possibly attenuating the upper side band of the 38 kc/s subcarrier in order to simplify R.B.R. receiver design. This will avoid having coders at the satellite transmitters, or decoders in the receivers unless these are required for monitoring.

N.D.R. Germany

The main studio for stereophonic recording is the new Concert Hall studio at Hanover. Since it came into service, almost all light music originating in Hanover, and all symphonic music, is performed in this studio, the older and smaller music studio being used for the orchestra only when on two or three occasions each year the Concert Hall is used for television. All music in the Concert Hall is recorded in stereophony only, regardless of whether it will be broadcast in stereophony or monophony. They claim (as do the Dutch) that the result is nearly always better in monophony than a straight forward monophonic balance. This is difficult to explain, but there is some evidence to support it in our own stereophonic experience. The Hanover stereophonic mixing desk uses valve amplifiers exclusively. The loudspeakers are discussed elsewhere in this report. The microphones are all of Neumann types, the stereophonic specimens being mainly a later form of the SM2 using different valves in the head amplifier. The microphone balance is based, as in the BBC, on general coverage of a crossed coincident pair, with subsidiary pairs, or individual monophonic microphones added, and steered by Panpots to fit the positions given by the main microphone pair. The results as heard from tapes were very good.

Hamburg has also a transportable stereophonic panel, which during our visit was being used to record a dance band type of orchestra. Microphone technique was similar to that of Hanover. Artificial reverberation was from an E.M.T. plate having two pick-up microphones, but these were being fed not into left and right channels but into M and S respectively. The studio (that used in 1954 by the N.W.D.R. Symphony Orchestra) was more reverberant than we should have considered appropriate for such music, but the results (in the early stages of this experimental recording) were quite good. The panel had six stereophonic channels and six monophonic channels.

N.D.R. broadcasts one to one and a half hours of stereophonic material each week day, but this consists of recorded music frequently interrupted by technical instructions and tests. Each Saturday and Sunday it broadcasts some stereophonic recorded programme material of entertainment value. We were told that Sender Freies Berlin has regular live stereophonic broadcasts.

7. TRANSMITTERS

The Medium Wave transmitters occupy one building on the Lopik site. Each feeds its own mast radiator. Both transmitters are twenty-eight years old and use Doherty modulation. In terms of power consumption they are very inefficient, and it is hoped to replace them in the next year or two. Nevertheless, working with limiters set to operate at 100% modulation with two to three milliseconds attack time and 500 milliseconds recovery time, they give remarkably distortion-free quality judged subjectively in comparison with most of the BBC Medium Wave transmitters.

The television and V.H.F. tower at Lopik is 365 m (1196 ft) high of which the first 100 m is a concrete cylinder containing the transmitters and working areas generally, the remainder being a stayed steel tube 2 m in diameter carrying V.H.F. television aerials in addition to the V.H.F. aerials for the doctor paging system already mentioned.

The television signals are received in Hilversum by cable from Bussum, thence by radio link to the tower from which they are sent by links to transmitters at Goes, Roermund Loon op Zand, Markels and Smilde. The V.H.F. aerials at Lopik alone give 100% coverage for the whole country[x], the links and other transmitters being necessary for the U.H.F. second television programme now starting. Fig. 10 shows one of the dishes for the fixed radio links.

In addition, two portable dishes are accommodated in a closed ring-shaped space on the floor below together with a large circular map of Holland with means for ascertaining the bearing of any place in the country. The dishes may then be lifted to any part of the circumference of the tower to face the direction from which an O.B. is originating.

8. OTHER VISITS

8.1 Amsterdam Concertgebouw

It was not possible to go to a concert in the large hall but a recital in the small hall proved rewarding. The acoustics seemed ideal for a chamber group (The Gaffino Kwartet were performing) and the sound quality during a piece in which the ensemble was accompanied by a quiet guitar was clear and quite pleasant. This was somewhat surprising as the hall is oval and we were seated near one of the foci. It is possible that the baroque decoration is sufficiently prominent to give reasonable diffusion.

8.2 Hanover Stadthalle

We paid a visit to the Stadthalle in Hanover. The larger of the two halls is elliptical, rather resembling the Royal Albert Hall, though smaller. The volume is 30,000 m^3 (1,100,000 ft^3) against the 3 million cubic feet of the Albert Hall. It has 3,666 seats and is used for banquets and boxing matches in addition to concerts.

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[x] Nevertheless, we understand there are V.H.F. transmitters also in North and South Holland.

In spite of an added conical inner ceiling, reflectors and diffusing irregularities, there are serious echoes and we had difficulty in believing the claim that the orchestral acoustics are praiseworthy.

On the other hand, a smaller rectangular hall on the same site struck us as being excellent. The dimensions were estimated as 75 ft x 60 ft x 40 ft with a balcony 9 ft wide all along the sides and back. This gives a volume of 180,000 ft3. The reverberation time was about $1\frac{1}{2}$ sec and decays noticeably smooth and uncoloured.

8.3 Hamburg State Opera House

Although the Opera House was occupied by almost continuous rehearsals for the season now running, we were allowed by the management to spend about half an hour in the theatre during a meal break, with the House Engineer as a guide.

The stage itself was the only part of the 1929 theatre left standing after the war and for some years opera was performed with both players and audience on the stage. Temporary fireproof bass absorbers were provided during this time consisting of $\frac{1}{2}$ mm aluminium sheets with cardboard sandwiched between.

At the same time work was started on the construction of a new auditorium to join on to the stage. This auditorium is hexagonal in plan, slightly longer back to front than side to side. The back wall carries four fairly shallow balconies, while the side walls are covered with boxes similar to those of the Royal Festival Hall. There are spotlight galleries crossing the ceiling at intervals and the roof, sloping upward from the proscenium, is stepped.

All these irregularities promote good diffusion and the decays of sound appeared smooth.

The stage is rectangular, 29 m deep x 37 m wide, with a proscenium arch 13 m wide and no apron. It is one of the biggest stages in Europe and is served by 10 m^2 hydraulic lifts. An orchestral pit is formed between the stage and the stalls; it is 10 m from back to front, of which 3 m width is covered by the stage apron.

The reverberation time was judged as 1.4 seconds with a maximum at about 1 kc/s. There are 1670 seats altogether, the most distant being about 45 m from the front of the stage.

During our visit, a demonstration of an artificial thunderstorm was given, using felt-covered drums rubbing against metal plates, just about good enough for opera.

Acoustic treatment is by veneered asbestos-cement board panelling.

There is a high level of traffic noise in the foyer at the back of the theatre but this is reduced to an acceptable level by well-constructed doors with "Ingerslev" type slotted jambs.

We were unable on this occasion to hear music in the theatre but the House Engineer said he preferred the upper balconies to the stalls where, he said, there were sometimes troublesome echoes.

The following day, one of the party was able to attend part of the dress rehearsal of a new opera by Krenek, to receive its first production a few days later. There was, of course, no audience present, but the general effect had ample reverberation with good clarity and good balance between chorus and orchestra. The orchestra sound was better in the top balcony where it had greater clarity and brilliance than in the rear stalls.

9. SUMMARY OF SALIENT POINTS

The observations which most impressed the party were as follows:-

1) The remarkable advance in stereophony in both countries. In Holland stereophonic programmes constitute a very large fraction of the sound broadcasting output and frequently compatible stereophony occupies both domestic services simultaneously. In Germany there is no regular stereophony service but in preparation for the future all light music is now being recorded in stereophonic form.

2) The over-riding control exercised by the Engineering Services over all technical operations, including those performed here by Programme Operations Department. There was marked discipline also over the non-engineering and programme contributors, as for example in the prohibition of smoking and unauthorised entry to studios.

3) The acceptance of at least 70 - 75 dB as the minimum mean isolation of the walls and roof of a studio, whatever its location.

10. REFERENCES

1. Kraemer, F.W., Lichtenham, G. and Oesterlen, D., "Der Grosse Sendesaal des N.D.R. in Hannover", Rundfunktechnische Mitteilungen, VII, No. 5, September 1963.

2. Struve, W., "Bau- und Raumakustik im Studio-Neubau des Bayerischen Rundfunks", Rundfunktechnische Mitteilungen, VIII, No. 1, February 1964, p.10.

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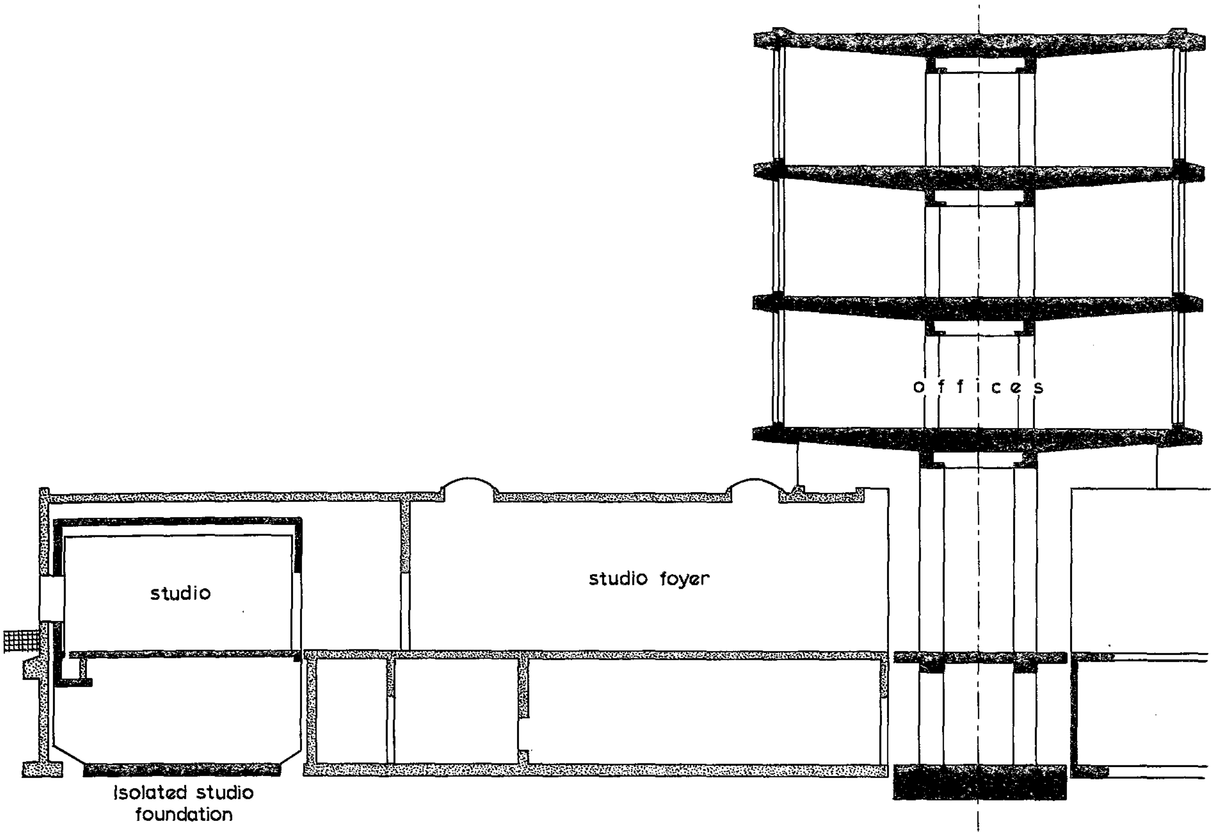

Fig. 1 R.N.W. studios Hilversum, showing isolation of studios from associated areas, and of offices from technical blocks

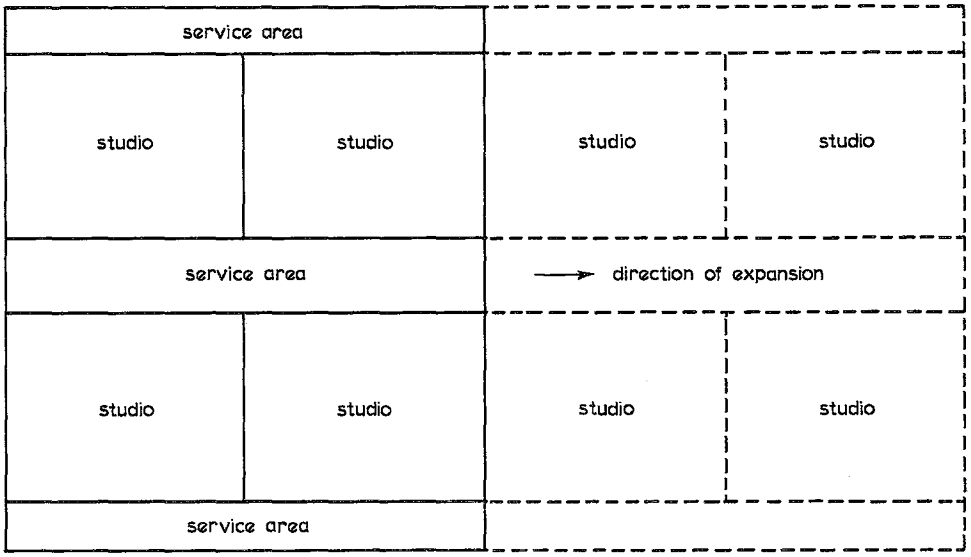

Fig. 2 Diagram showing principle of linear expansion

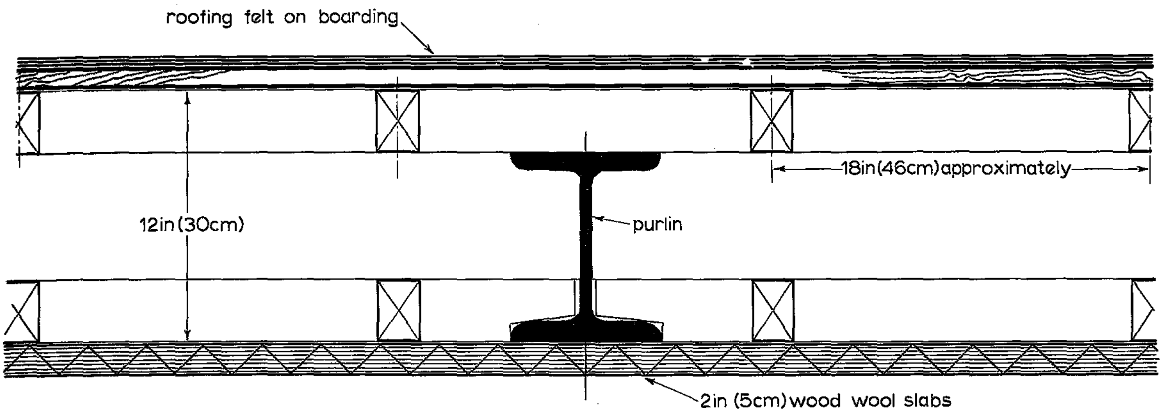

Fig. 3 Construction of television studio roofs at Radio City, Hilversum

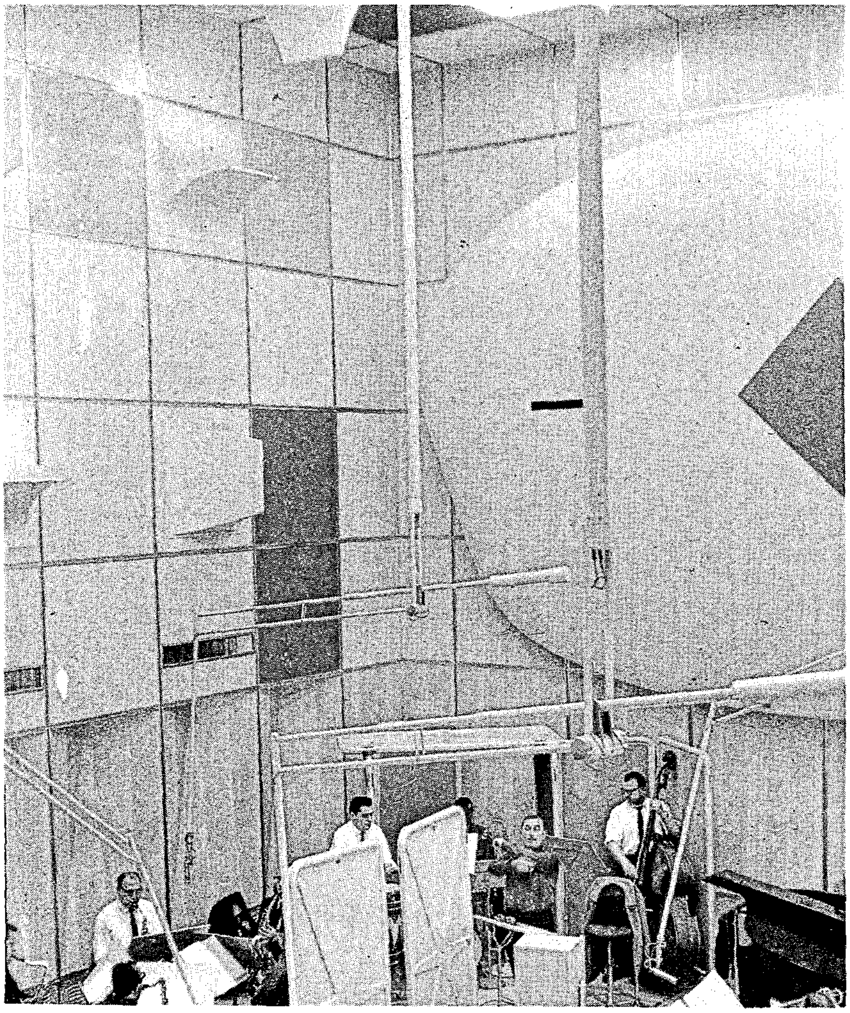

Fig. 4 A music studio in V.A.R.A. building, Hilversum, showing diffusers on walls, microphone suspension equipment and acoustic screens

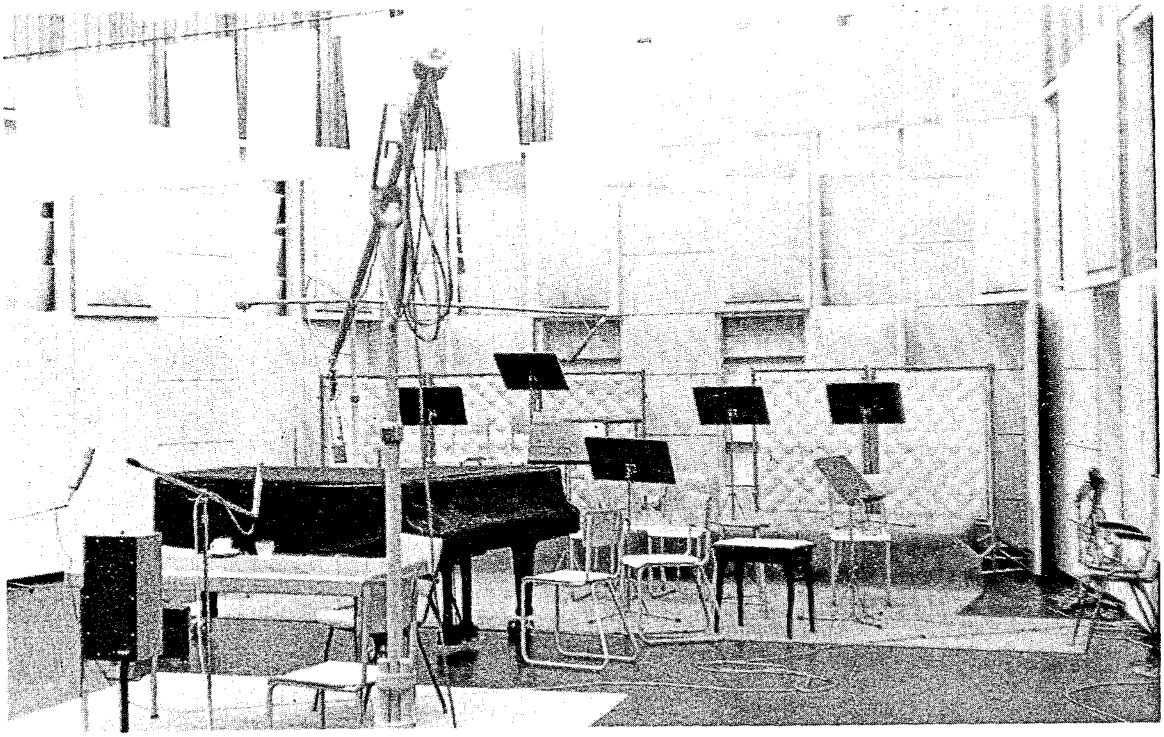

Fig. 5 A music studio in R.N.W., Hilversum, showing variable acoustic treatment and correction by fibreglass batts

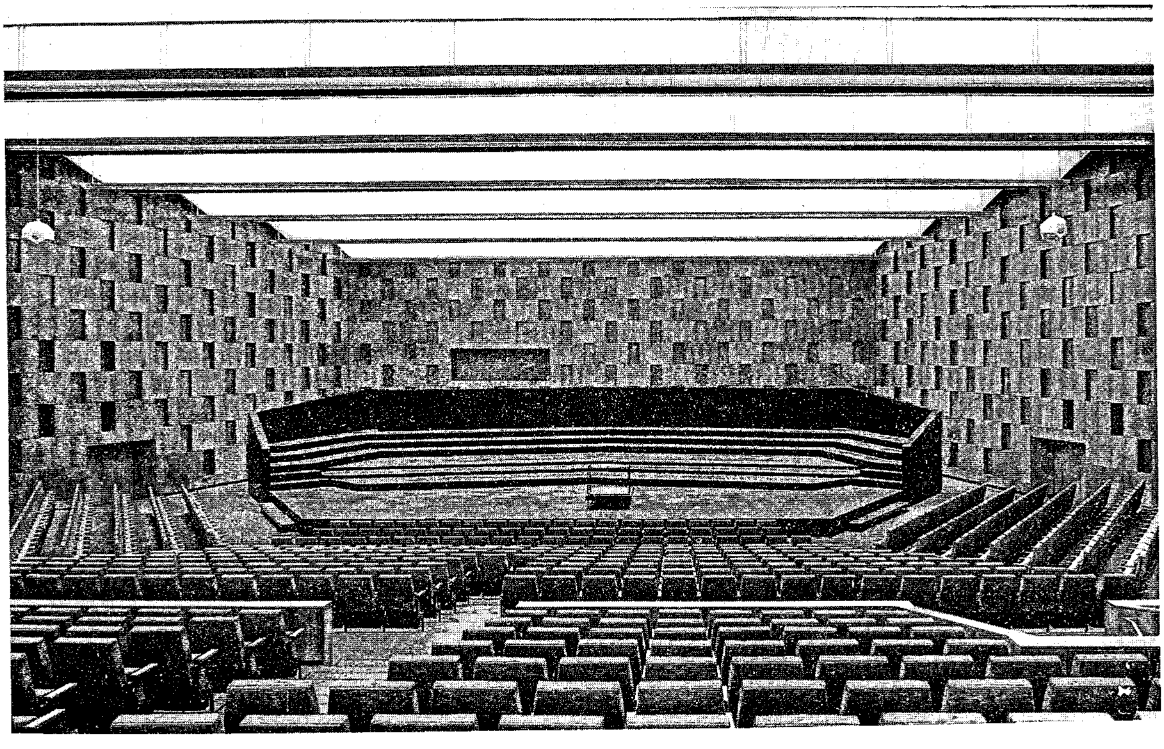

Fig. 6 Interior of Hanover large music studio, showing coffered treatment on walls and reflector behind stage

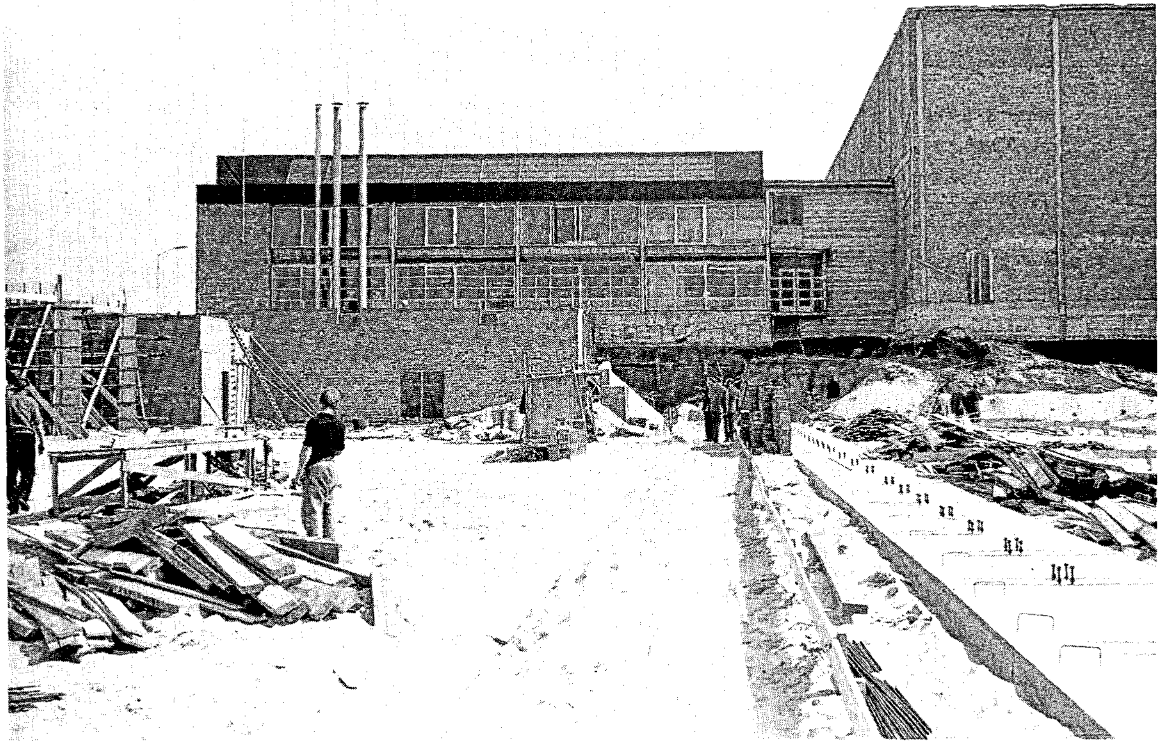

Fig. 7 Construction of television studios in Hilversum on deep stratum of sand

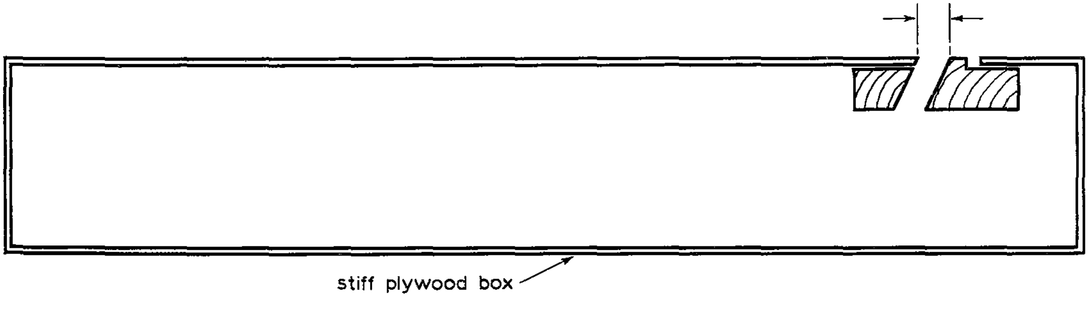

Fig. 8 Section through Helmholtz resonator (v. Leeuwen)
approximate length 3ft 6in (1m)

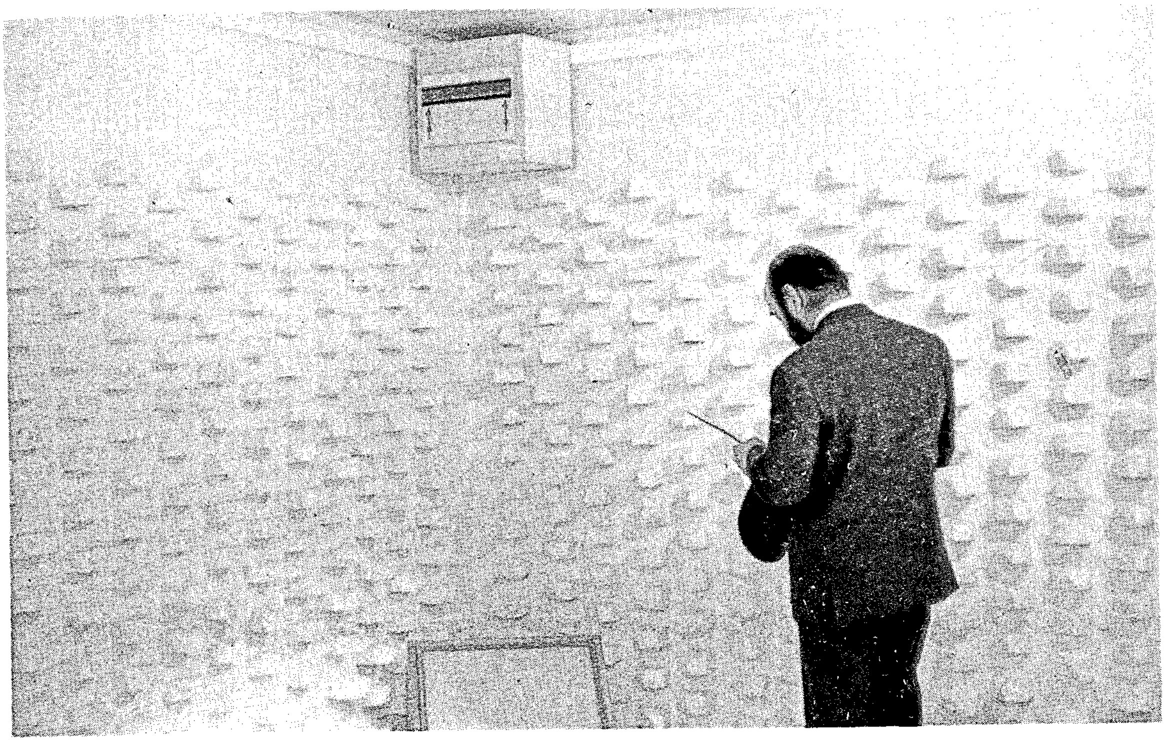

Fig. 9 Helmholtz resonator absorber and brick diffusers

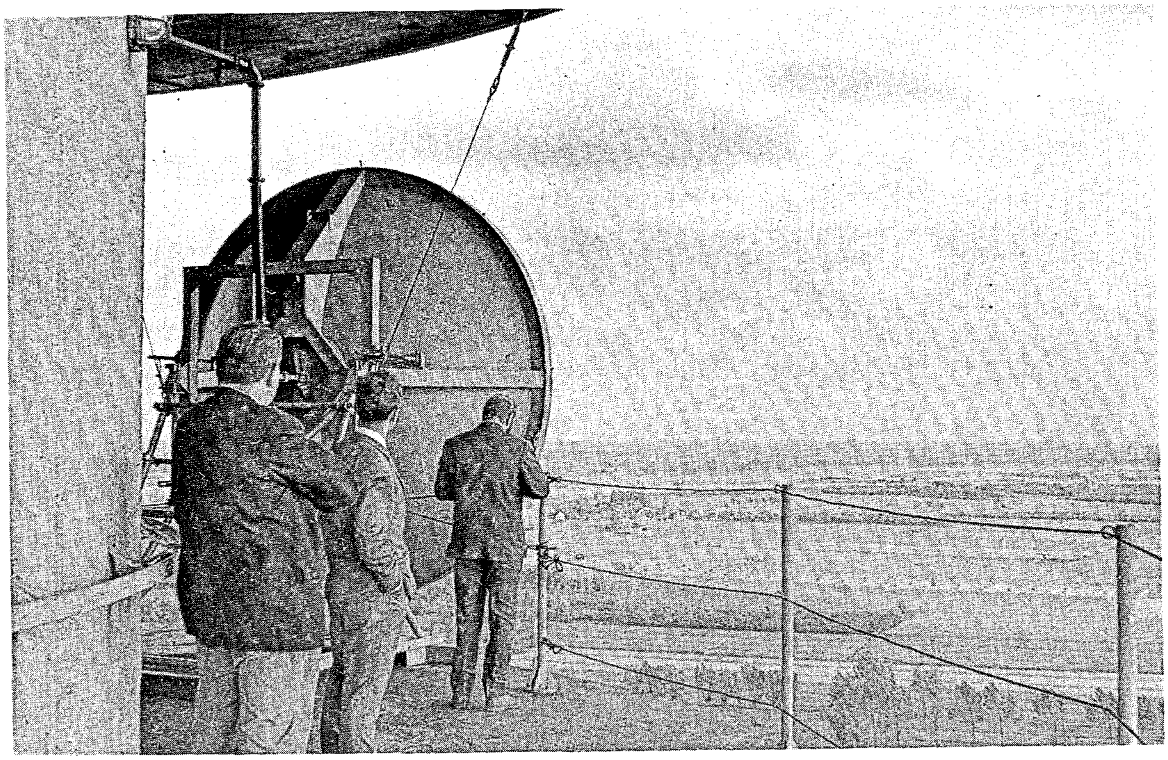

Fig.10 Radio link dish at Lopik